WAVEGUIDE FILTERS SUPPRESSING HIGNER-ORDER PASSBANDS

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Abstract

A new class of waveguide bandpass filters with suppressed higher-order passbands is described, designed, theoretically and experimentally verified. Methods of minimal autonomous blocks and mode matching are used for analysis. Attenuation of higher-order passbands is achieved by adding waveguide shunt elements to the filter structure.

Keywords:

1. Introduction

A new type of waveguide bandpass filters with attenuation of higher-order passbands has been proposed in [1]. Results of the work [1] are based on solution by the mode matching technique (MM) [2]. The first filter design was done using results obtained by the method of minimal autonomous blocks (MAB) [3], but these results have not been published yet.

The frequency characteristics of all transmission line filters are periodic with alternating stop and pass bands. Higher-order passbands are not acceptable for some applications. We solved this problem in [1] by adding to the filter structure waveguide elements. These elements provide significant losses to the filter above their cut-off frequency. The filter structure is shown in Fig. 1. The filter design itself was done according [4].

2. Theory, results

The MAB method used for the solution is shortly described in [3], where some applications are shown,

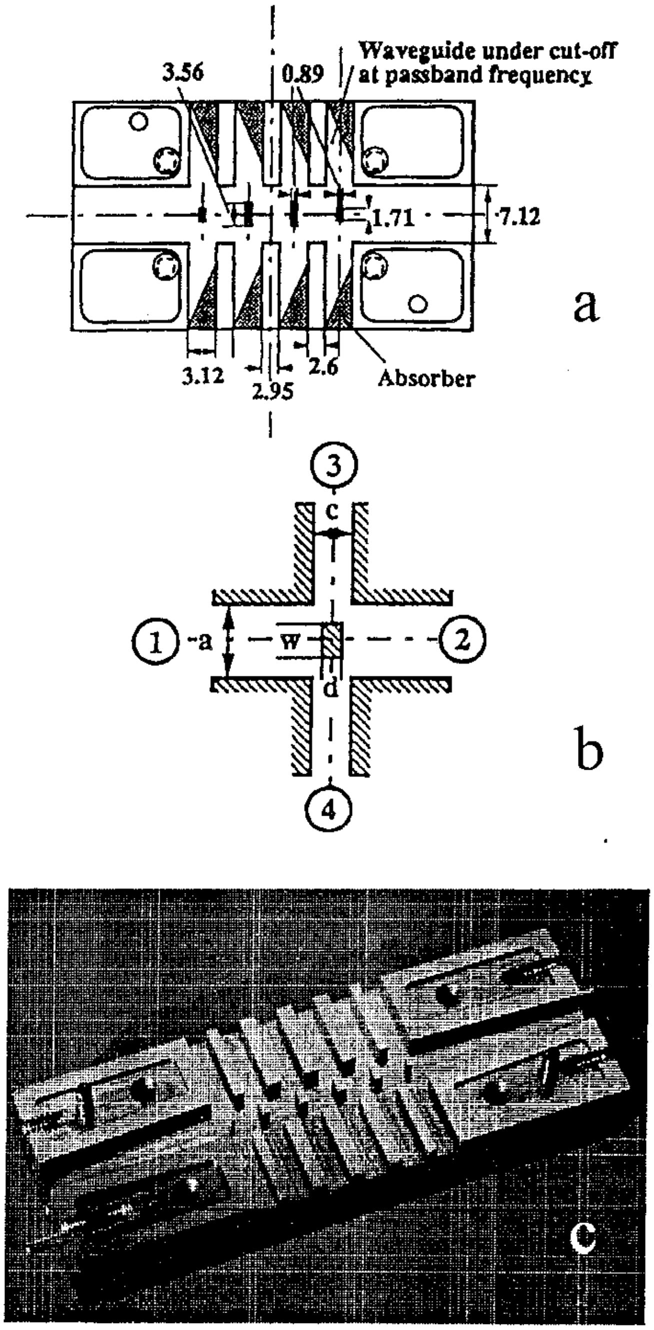

Fig.1
Proposed filter structure.
a) designed three resonator filter,
b) analyzed waveguide crossing with an inductive post,
c) manufactured five resonator filter [1].

origin of this method is based on the work [5], where it is explained in detail.

The first step in the filter design is analysis of the waveguide crossing with the inductive post (Fig. 1). Its transmission properties in dependence on the inductive post width were calculated. Results are in Fig. 2, reference plane is in the center of the junction, frequency is 35 GHz.

The filter design is based on an equivalent circuit formed by shunt inductances (calculated from transmission properties of the waveguide junction - Fig. 2) and transmission line resonators. The elements of this circuit are calculated according [4]. Post widths are chosen in such a way that the waveguide junctions exhibit the same |S21| as the shunt inductances of the equivalent circuit. Finally the resonator lengths were corrected according to the phase angle differences between equivalent inductances and waveguide junctions (Fig. 2).

A three resonator filter for 35 GHz (Tchebyscheff, 0.1 dB ripple, Ka-band waveguide) with equal widths of all shunt waveguides was designed applying two different junctions with w= 1,71 mm and w = 3.56 mm (Fig. 1).

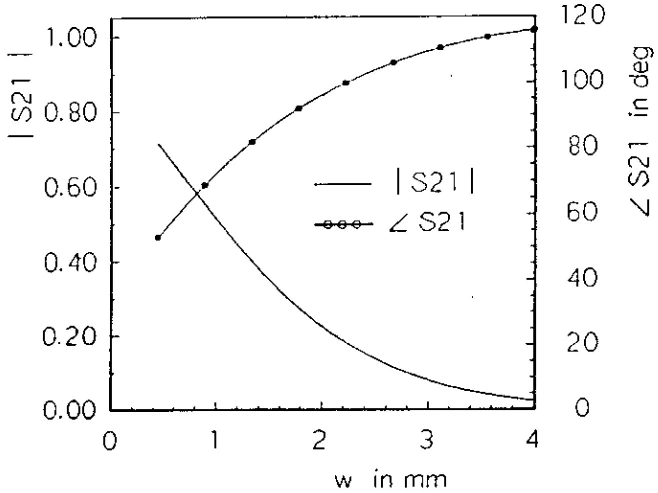

Fig.2
S21 of a waveguide junction with a shunt post in dependence on post width at f=35 GHz

The transmission characteristics of these junctions are shown in Fig. 3 (results of the MAB solution). Fig. 4 shows theoretical (MAB) and experimental data of the designed filter. A slight frequency shift between curves is caused by dimension inaccuracies in manufactured structure as well as by the MAB method itself [3]. The strong ripple in theoretical curve above frequency 50 GHz is caused again by MAB method. The space blocks used in the computational procedure are not small enough in comparison to wavelength that changes here very fast. The sufficient agreement between theory and experiment up to 110 GHz was achieved. Further improvement of the filter characteristic above passband can be achieved by optimizing properly shunt waveguide widths [1].

The significant suppression of higher-order passbands can be seen in Fig. 4. This desired effect is moreover documented in Fig. 5, where frequency characteristics of three filter types are plotted (calculated by MM technique).

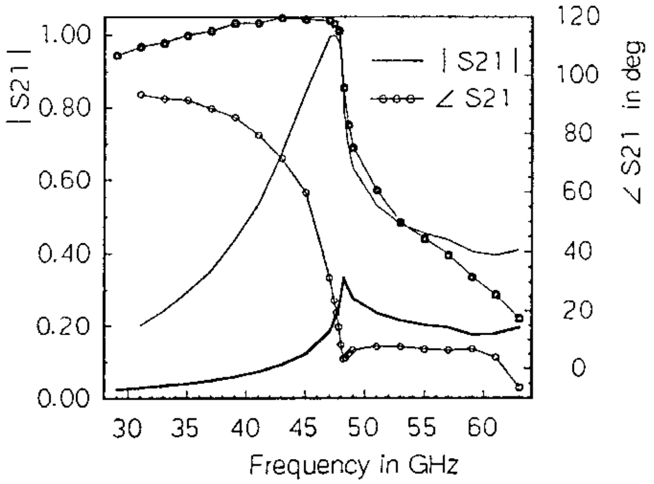

Fig.3
Transmission properties of two junctions with w=1.71mm and w=3.56mm

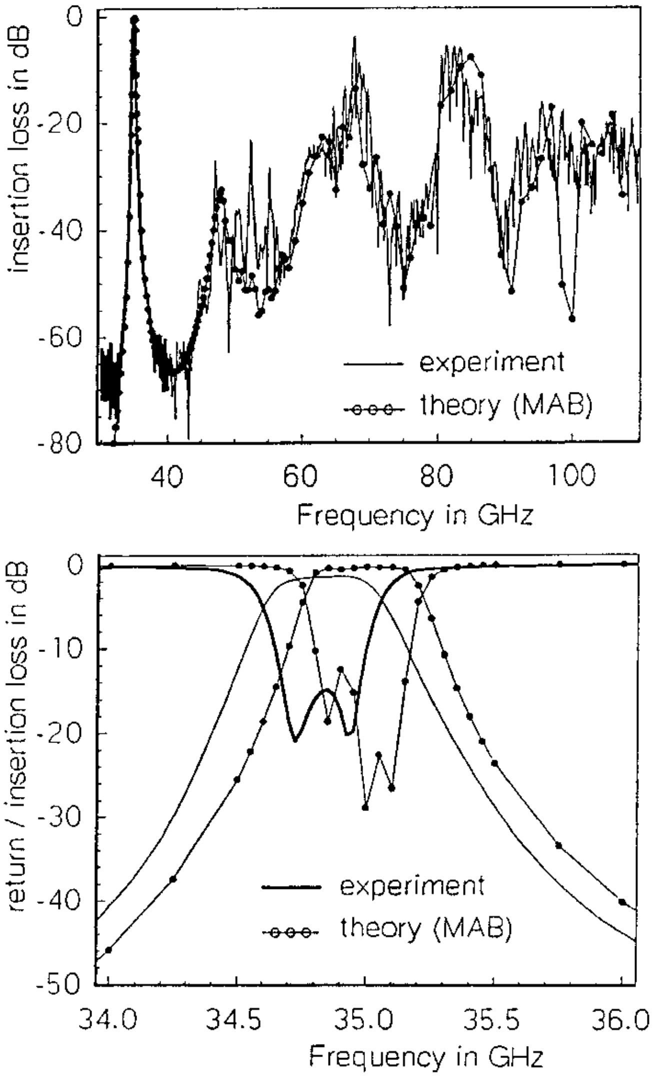

Fig.4
Experimental and theoretical transmission properties of the filter from Fig.1

Comparing filter characteristics in Fig. 5 the better behaviour of the proposed new filter structure is clearly visible.

3. Conclusions

The new class of waveguide bandpass filters has been proposed. The higher-order passbands are suppressed by shunt waveguide elements that produce aditional losses to the filter at frequencies above their cut-off. The three resonator filter with the bandwidth 0.5 GHz at 35 GHz was designed and tested. The agreement of theory and experiment is very good.

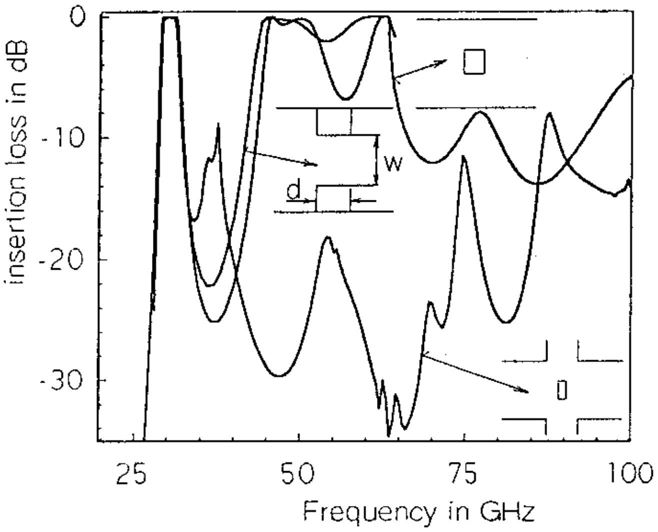

Fig.5

Comparison of S21 of 2 GHz filters with three resonators

Filter with inductive irises:

w_1=4.5mm, w_2=3.5mm, d_1=1.16mm,
d_2=1.12mm, l_1=4.85mm, l_2=5.49mm.

Filter with inductive posts:

w_1=0.1mm, w_2 =1mm, d_1=d_2=0.2mm,
l_1=5.53mm, 1_2=6.03mm.

Filter with inductive posts and shunt waveguides:

c_1=4.2mm, c_2=5mm, w_1=0.8mm, w_2=1.4mm,
d_1=0.5mm, d_2=1mm, l_1=1.87mm, l_2=2.76mm.

4. References

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Jan Machač was born in the Czechoslovakia on April 1, 1953. He graduated at the Faculty of Electrical Engineering, Czech Technical University in Prague in 1977 an obtained the PhD degree from the Institute of Radioegineering and Electronics, Czechoslovak Academy of Sciences in Prague in 1982. He was active at research in the field of light emitting superconductor devices and semiconductor photodetectors. He was appointed to a lecturing post at the Department of Electromagnetic Field, Faculty of Electrical Engineering, Czech Technical University of Prague in 1984 as a senior lecture and as associate professor since 1991. His field of interest includes solution of electromagnetic fields by numerical methods in passive elements of microwave and millimeter wave systems.

Wolfgang Menzel - information not available in time of publication.